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# Agricultural Competitiveness: The Case of the United States and Major EU Countries

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**Agricultural Competitiveness: The Case of the United States and Major EU Countries.** Munisamy Gopinath, Carlos Arnade, Mathew Shane and Terry Roe, Commercial Agriculture Division, Economic Research Service, U.S. Department of Agriculture. Staff Paper No. AGES 9613.

**Abstract**

Growth in the agricultural GDP of four major European countries is compared with U.S. agricultural growth for the period 1974-1993. The agricultural sector's domestic terms of trade with the rest of the economy is taken into account along with economy-wide factor market adjustments. For all the four countries-- Denmark, France, Germany, and the U.K.-- the effects of declining real prices and changes in input levels on growth in agricultural GDP are relatively small on average. Total Factor Productivity (TFP) appears to be the major contributor to European agricultural GDP growth. TFP is the major source of growth in U.S. and EU agricultural GDP, but its rate of growth in the United States is lower than the European countries for the same period. The declining real prices for U.S. agriculture had a large effect on its GDP as compared with the EU. However, in the late 1980s and early 1990s, the effects of declining real prices and declining rates of growth in TFP on European agriculture were relatively large. In the longer run, the relative competitiveness of U.S. agriculture is largely dependent on its ability to sustain and increase growth in TFP.

**Keywords:** Growth, agriculture, Europe, United States, total factor productivity, competitiveness.

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# Summary

This paper focuses on the sources of agricultural growth in major countries of the European Union (EU) and contrasts them with the sources of growth in U.S. agriculture. Growth in agricultural GDP is decomposed into level and rate effects. Rate effects of technology lead to persistent changes in rates of growth of GDP. Changes in prices/factors bring about changes in the level of GDP and not necessarily the rate of growth. The nature and magnitude of these effects are important public policy issues, since each of these effects can be greatly influenced by government programs.

For four of the major European countries (Denmark, France, W. Germany, and the U.K.), agricultural GDP growth was high relative to overall GDP growth, suggesting that agriculture was gaining domestic competitiveness. Although total factor productivity (TFP) is the major contributor to growth in EU agriculture, its rate of growth exhibits high variability and a declining time trend. On average, the real price declines for agricultural commodities were modest suggesting a large degree of insulation from world price movements. However, after the introduction of supply control measures (1988-93), real prices have declined, reflecting a move by the EU toward world market conditions.

For the United States, our separate analyses show that the ratio of agricultural to non-agricultural TFP growth is about 10 (2.17 percent TFP growth in agriculture and 0.21 percent TFP growth in the entire economy during 1974-91). For the EU countries, agricultural TFP ranged from 6.4 percent for the U.K. to 2 percent for Germany. Economy-wide TFP growth rates, from a different study, vary between 1.7 percent for U.K. to 2.9 percent for France. This suggests that the ratio of agricultural to non-agricultural productivity in major EU countries is between 1 and 4. As competitiveness is viewed as a relative concept in this study, U.S. agriculture has remained competitive largely due to its comparative agricultural productivity.

Since TFP growth in U.S. agriculture is strongly associated with public R&D and infrastructure, the relative competitiveness of U.S. agriculture, in the long run, is likely to depend on its ability to sustain and increase growth in TFP.

# Agricultural Competitiveness: The Case of the United States and Major EU Countries

Munisamy Gopinath, Carlos Arnade, Mathew Shane and Terry Roe*

## I. Introduction

This paper focuses on the sources of growth in European Union (EU) agriculture and contrasts them with the sources of growth in U.S. agriculture. Growth in European agricultural output has been relatively high over the past few decades and coincident with its support of agriculture (Arnade 1995, Bureau et al. 1995).[1] There is a belief that this growth has been stimulated by high and stable prices that producers receive under the European Union's Common Agricultural Policy (CAP). Others dispute this notion and claim that yield growth is a result of technical change which would continue without price incentives. From the perspective of U.S. agriculture, the relatively high growth rates of European agriculture are important. The EU, as a whole, has become not only self-sufficient in most of its own agricultural markets, but also a major competitor to the U.S. in world agricultural export markets. This growth experience suggests that U.S. agriculture might be losing 'competitiveness' relative to the EU countries. However, this conclusion needs to be tempered by whether the growth in EU agriculture has been artificially sustained by the CAP and, therefore, whether it is likely to continue under CAP reform. An analysis of the underlying factors to that growth will provide insight into that longer run question.

This study decomposes growth in agricultural GDP into <u>level</u> and <u>rate</u> effects.[2] The level effects are the result of changes in inputs and prices and are short-run in nature (often for only a single time period), while the rate effects from total factor productivity (TFP) tend to be longer run dynamic sources of growth. Essentially, growth driven by level effects is typically not sustainable in the longrun, particularly if policy artificially distorts sector prices upward and otherwise slows the adjustment associated with the competition among a country's agricultural and non-agricultural sectors for economy-wide resources.

The nature and magnitude of these effects are important public policy issues since each of these effects can be greatly influenced by government programs. In addition, many of the sources of TFP growth in agriculture are likely to be external to the sector. These technological externalities (which are discussed in the "new" growth literature, Lucas 1993, Romer 1990 and Stokey 1988) include public investments in R&D, public infrastructure, patent protection, learning-by-doing, and other public investments that seek to counter the market's failure to reward the factors of production for their <u>full</u> contribution to productivity.

The analysis draws on the sectoral GDP function developed by Gopinath and Roe (1995), following Diewert and Morrison (1986), to compute the level effects of inputs and prices and the rate effects of total

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[1] Although these papers use different techniques, all come to the same two major conclusions: growth in multifactor productivity (MFP) has been significantly higher in European agriculture than in U.S. agriculture, particularly in the 1970's. In the 1980's, the gap between the rates of MFP growth has declined but European growth rates remain higher than those in the United States.

[2] Rate effects lead to persistent changes in rates of growth of GDP. Changes in prices/factors bring about changes in the level of GDP and not necessarily, the rate of growth.

factor productivity on the growth in the "real value" of European and U.S. agricultural output. The non-parametric estimates of the contributions to growth in agricultural GDP are derived by applying the Quadratic approximation lemma (Diewert, 1976) to the sectoral GDP function. Data for the period 1973-93 from *Spel* (Eurostat), *Economic Accounts for Agriculture* (OECD), Ball et al. (1993, 1995) and *STARS* (World Bank) are used to derive Tornqvist indices of three outputs and eight inputs (prices and quantities) for this purpose. Data and choice of countries are outlined in section IV.

Results indicate that TFP is the major source of growth in the major European (Denmark, France, Germany, and the U.K.) and U.S. agricultural sectors, on average, over 1974-93. For the United States, the level effects from prices are significantly negative, while inputs have a small positive contribution to growth during the same period. With the exception of Germany, the decline in agriculture's terms of trade with the rest of the economy is relatively lower in the European countries, which along with large rates of growth in TFP has led to relatively large growth rates in GDP. However, since 1988, declining real prices and declining rates of growth in TFP have sharply reduced the growth of European agriculture. In contrast, U.S. agriculture shows a relatively stable growth in its TFP and less adverse effects from declining real prices. Hence, the relative competitiveness of U.S. agriculture is likely to depend, largely, on its ability to sustain higher growth in TFP.

## II. Competitiveness: A Definition

The concept of competitiveness has been used in a broad set of contexts. In general, the concept is poorly defined.[3] The following provides an analytical definition of the concept "competitiveness." It focuses on a sector rather than the whole economy. As we see it, competitiveness is a relative concept with two dimensions, domestic and international. If within an economy, say the United States, the rate of growth in agriculture's real GDP exceeds that of the economy, i.e.,

$$d(\ln GDP_A)/dt \;>\; d(\ln GDP)/dt \qquad (1)$$

then agriculture (A) is increasing its competitiveness relative to the other sectors of the economy. In other words, agricultural GDP is growing relative to the rest of the economy. The derivative in the numerator and denominator of (1) is total rather than partial, and suggests that the sources of this change can be decomposed into level effects of prices and factors, and the rate effects of total factor productivity (TFP). Now, consider a comparison of agricultural sectors of two countries, say that of the United States and country 'X':

$$\frac{d(\ln GDP_{A,\,US})/dt}{d(\ln GDP_{US})/dt} \;>\; \frac{d(\ln GDP_{A,\,X})/dt}{d(\ln GDP_X)/dt} \;>\; 1 \qquad (2)$$

If the real GDP of the agriculture relative to the non-agriculture of one country is growing compared with that of another, then we say the first country is gaining bilateral agricultural competitiveness over the

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[3]An economic definition without an analytic counterpart is not useful in that it either allows almost all cases to be included or no cases. This is particularly true for rather vague definitions applied to the macro economy such as: "What we should mean by 'competitiveness' at the national level...is the ability to sustain...an acceptable growth in the real standard of living of the population with an acceptably fair distribution, while efficiently providing employment for all who can and wish to work...." Landau (1992). Based on this definition, it would be extremely hard to distinguish between the competitiveness of different economies or sectors.

second. In this case, U.S. agriculture is growing relative to country X and is said to be gaining bilateral competitiveness. Note this is again a function of the underlying sources of growth in agricultural GDP. For the U.S. to be globally competitive, it has to be the case that :

$$\frac{d(\ln GDP_{A,\,US})/dt}{d(\ln GDP_{US})/dt} > \frac{d(\ln GDP_{A,\,W})/dt}{d(\ln GDP_{W})/dt} \tag{3}$$

where, $GDP_{A\,W} = \sum_x GDP_{A\,x}$ is world agricultural GDP. In a competitive economy with no trade distortions this result implies that in the aggregate and on average over a period, the U.S. farmers are competing more successfully for world consumers of food, including the U.S. consumers, than are the rest of the world's farmers[4].

Under conditions discussed below, GDP growth can be shown consistent with profit maximization at the firm level. Consequently, the above definitions imply that the competitiveness of a sector can be viewed as its ability to (I) grow by attracting resources (level effects) and/or lower production costs (rate effects) and (ii) in a broad based sense, increase market share. Recall that the nature and magnitude of these effects are important public policy issues, since each of these can be significantly affected by government policies and programs. In addition, the distinction between level and rate effects has implications for sustaining the competitiveness of a sector. For instance, assume country X has high price support policies (which are level effects) while the U.S. agricultural growth is dominated by rate effects or growth in TFP. The level effects result in one time benefits and have to recur periodically to sustain growth, but the rate effects are long-run in the sense that they do not perish in one time period. Further, annual increases in price supports can increase growth in real GDP, but this source can be artificial and not sustainable when prices are supported above world market levels. In this example, the U.S. agriculture will maintain its competitiveness in the long-run, while country X may have high growth rates during the period of time of increasing price supports. However, increasing price supports only come about through growing budget support which over time becomes increasingly difficult to sustain.

Krugman (1996) points out that productivity of a sector per se has little, if anything, to do with international competitiveness. Instead, it is relative sectoral efficiency gains (in the case of this study, efficiency gains in the U.S. agriculture relative to U.S. non-agriculture compared with that of its major competitors) that determines trade performance. While productivity growth of a sector or an economy is vital to a country's standard of living, absolute productivity comparisons across countries alone provide no insights into competitive advantage. The productivity of agriculture relative to non-agriculture in the U.S. compared with that of its major competitors determines international competitiveness or as Krugman suggests "the success of a country depends not on absolute but on comparative productivity advantage" (p. 272).

## III. The Model

Consider an economy with two outputs (vectors) $y_j$ , j = primary Agriculture (A), and Non-agriculture (N) and three categories of inputs ($v_A$, $v_N$, $v_E$ ) where the input vector $v_j$, j = A, N is specific to sector `j' and $v_E$ is a vector of economy wide factors, such as labor and material inputs. Following Woodland (1982), define the economy wide GDP function as:

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[4]Of course, at the individual commodity level, some countries may be more competitive than the United States. Moreover as the denominator of equation (3) is an estimate of mean growth rates, some countries included in the aggregate may have larger growth rates than the United States.

$$G(p_A, p_N, \bar{v}_A, \bar{v}_N, \bar{v}_E \,;\, y) = \max_X \{ \textstyle\sum_{j=A,N} p_j Y_j(v_j, v_E^j; y_j) \} \tag{4}$$
$$X \quad \{ (v_A, v_N, v_E^A, v_E^N) : v_A \leq \bar{v}_A,\ v_N \leq \bar{v}_N,\ v_E^A + v_E^N \leq \bar{v}_E \}$$

and $Y_j(v_j, v_{Ej}, y_j)$ for j=A,N is a constant returns to scale or vintage production function (Diewert, 1980). The Lagrangian multipliers of this (constrained) maximization problem namely ($\lambda_A, \lambda_N, \lambda_E$) are the shadow prices for the two sector-specific inputs and one economy wide factor. The feasible set X is bounded by the endowments of the private sector. The variable '$y_j$' in $Y_j$ is an 'externality' in the sense that it is not a choice variable of the individual firm. It broadly represents the "level of efficiency" or "technology" of the economy. The sources of efficiency gains include learning-by-doing, and public investments in infrastructure, research and development, and other social investments. Since most of these sources of efficiency gains are external to and not necessarily made within a sector, they are referred to as 'externalities'.

The envelope properties of G (see Woodland, 1982) imply the supply function $y_j$ (for j = A, N) and the factor rental rate or inverse demand function $\lambda_j$ (for j = A, N, E):

$$\frac{\partial G}{\partial p_j} = y_j(p_A, p_N, \bar{v}_A, \bar{v}_N, \bar{v}_E; y_j); \qquad \frac{\partial G}{\partial v_j} = \lambda_j(p_A, p_N, \bar{v}_A, \bar{v}_N, \bar{v}_E; y_j) \tag{5}$$

Given the solutions ($v_E^{j*}$, $v_A$, $v_N$) to the problem in (4), redefine it as:

$$\max_X \{ \textstyle\sum_{j=A,N} p_j Y_j(v_j, v_E^j; y_j) \} \tag{6}$$
$$X = \{ v_A \leq \bar{v}_A,\ v_N \leq \bar{v}_N,\ v_E^j \leq v_E^{j*} \text{ for all } j \}$$

Proposition:1[5]

The solution to problem (6) is given by:

$$G(p_A, p_N, \bar{v}_A, \bar{v}_N, \bar{v}_E; y) = \textstyle\sum_{j=A,N} g_j\,(p_j, v_E^{j*}, \bar{v}_j; y_j) \tag{7}$$

$g_j$, referred to as the 'sectoral GDP' function, under certain regularity conditions, completely characterizes the underlying technology set (following Diewert, 1974). This product function is homogeneous of degree one in each of $p_A$, and ($v_E^{A*}$, $v_A^*$) and has the same envelope properties as the economy wide GDP function. $g_A$ and its specific (translog) functional form are the basis for the non-parametric analysis (see Kohli, 1993 for the terminology) of contributions to growth in sectoral GDP.

The agricultural sector's GDP function is given by $g_A$ (for notational convenience g, hereafter) with three outputs , seven sector specific inputs and one economy wide input (see the data section for a description). For given real prices[6] and sector-specific inputs, and the quantity of the economy wide and intermediate

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[5]See Appendix.II of Gopinath and Roe (1995) for proof.

[6]We derive the real prices by deflating the sectoral price indices by a GDP deflator, in principle, discounting them for average price increases in the economy.

inputs used in this sector, define the period 't' theoretical productivity index (following Diewert and Morrison, 1986 who provide indices for an economy wide GDP function) as:

$$R^{t}(p, v_E^{A}, \bar{v}_A) = \frac{g(p, v_E^{A}, \bar{v}_A ; Y_A^{t})}{g(p, v_E^{A}, \bar{v}_A ; Y_A^{t-1})} \tag{8}$$

$R^t$ is the percentage increase in sectoral GDP (valued at reference output prices) that can be produced by the period t technology relative to the period t-1 technology. Two special cases of $R^t$ are:

$$R_L^{t} \equiv \frac{g(p^{t-1}, v_E^{A,t-1}, \bar{v}_A^{t-1} ; Y_A^{t})}{g(p^{t-1}, v_E^{A,t-1}, \bar{v}_A^{t-1} ; Y_A^{t-1})}; \quad R_P^{t} \equiv \frac{g(p^{t}, v_E^{A,t}, \bar{v}_A^{t} ; Y_A^{t})}{g(p^{t}, v_E^{A,t}, \bar{v}_A^{t} ; Y_A^{t-1})} \tag{9}$$

$R_L^t$ is a Laspeyres type index which uses period t-1 output prices and primary input quantities as references, while $R_P^t$ is a Paasche type productivity index based on period t prices and quantities. Since the two indices in (9) are not observable, a geometric mean of the two can be obtained using a translog functional form for the sectoral GDP function. For an explicit specification refer to Appendix III of Gopinath and Roe (1995). Given the translog functional form and the assumption of competitive profit maximization, it follows that

$$g(p^{t}, v_E^{t}, v_A^{t}; Y^{t}) \equiv \lambda_E^{t} v_E^{t} + \sum_l w_l^{t} v_l^{t} \equiv \sum_k p_k^{t} y_k^{t} \tag{10}$$

where, $v_E$ is the quantity of economy wide factor used in this sector and **w** is the vector of sector specific factor returns. Following Diewert and Morrison (1986), a geometric mean of the Laspeyres and Paasche index is derived as:

$$(R_L^{t} R_P^{t})^{\frac{1}{2}} = \frac{a}{b^{*}c^{*}e} ; \qquad \text{where} \quad a = \frac{p^{t} y^{t}}{p^{t-1} y^{t-1}} \tag{11}$$

$$\ln b = \frac{1}{2} \sum_{k=1}^{K} \left(\frac{p_k^{t} y_k^{t}}{p^{t} y^{t}} + \frac{p_k^{t-1} y_k^{t-1}}{p^{t-1} y^{t-1}}\right) \left(\ln \frac{p_k^{t}}{p_k^{t-1}}\right)$$

$$\ln c = \frac{1}{2} \sum_{l=1}^{L} \left(\frac{w_l^{t} v_l^{t}}{p^{t} y^{t}} + \frac{w_l^{t-1} v_l^{t-1}}{p^{t-1} y^{t-1}}\right) \left(\ln \frac{v_l^{t}}{v_l^{t-1}}\right) \tag{12}$$

$$\ln e = \frac{1}{2} \left(\frac{\lambda_E^{t} v_E^{t}}{p^{t} y^{t}} + \frac{\lambda_E^{t-1} v_E^{t-1}}{p^{t-1} y^{t-1}}\right) \left(\ln \frac{v_E^{t}}{v_E^{t-1}}\right)$$

Note that the right hand side of (11) can be obtained using aggregate price and quantity data. In (11), **a** is growth in real value of output, **b** is a translog output price index, so **(a/b)** is an implicit output quantity index, while **c** and **e** are a primary and economy wide input quantity indices. Therefore, **(a/b*c*e)** denotes a productivity index. Individual real price and input contributions to growth in real agricultural GDP can be obtained by disaggregating the indices in (12) (Diewert and Morrison,1986). The output (real) price effect for each good k is given by $\ln b_k$ while, for each input l, input level effect is given by $\ln c_l$.

For instance, $b_k$ is interpreted as the change in farm real GDP (between periods t and t-1) attributable to change in real price of the kth good from $p_k^{t-1}$ to $p_k^t$ holding other prices (including the economy wide input price) and all inputs constant. Equations (11), and (12) comprise the key components of the non-parametric analysis.

The index (9) is akin to Solow's residual, total factor productivity (TFP), and referred to as a 'rate effect' since, in the context of competitive markets and constant returns to scale technologies, it encompasses sources of technological change that are not necessarily among the choice set of producers. Examples include "spill-in" effects from new ideas, learning-by-doing and expansion of knowledge leading to increased efficiency that, while requiring resources to produce, are typically not taken into account when individual producers make production choices. These types of effects are common to the endogenous growth literature where markets fail to internalize technological externalities. Note also that the efficiency gains in other sectors of the economy enter the jth sector's procurement vector v. However, empirically TFP also includes unanticipated changes in exogenous variables such as weather and others (e.g., the oil price shocks of early and late 1970's).

## IV. Data and Choice of Countries

The technique outlined in the above section was applied to data from four European countries, Denmark, England, France, and W. Germany (referred to as Germany) from the years 1973 through 1993 and compared with results obtained for the United States elsewhere (Gopinath and Roe, 1995).

### A. The United States

Quantities and prices for four outputs, meat, other livestock (referred to as dairy), grain and other crops are derived as Tornqvist indexes. Similarly, hired labor (an economy-wide resource), family labor, real property, materials and other capital are the five inputs for which prices and quantities are derived as Tornqvist indexes. See Ball et al. (1995) for the construction of the data series for U.S. agriculture. The GDP deflator series published by the Department of Commerce is used to obtain real agricultural output prices.

### B. European Countries

The countries were chosen on the basis of the degrees to which they compete with the United States. All countries, except Denmark, compete with the United States in world wheat markets. France and the United States generally compete in the same markets (countries) for wheat exports. Each country is also a major producer of livestock products, particularly beef and pork, and thus compete with the United States in these areas. In contrast, Southern European countries (Italy, Spain, Portugal, Greece) export few products in common with the United States. Holland and Belgium do not produce enough output of competing goods to be considered a major competitor.

The major sources of data were the *Spel* data base of Eurostat and the *Economic Accounts for Agriculture* (*EAA*) from OECD. The *Spel* data base was used to obtain most of the outputs and inputs and their unit values for the period 1973 to 1993, except capital and land. Data from *EAA*, OECD on the value of labor, capital and intermediate inputs employed in agriculture are obtained for the same period. The GDP deflator for each of the four countries was taken from the *STARS* data series of the World Bank. We have adopted techniques similar to Ball et al. (1996) in the construction of EU time series. However, the intermediate input quantity index was not adjusted for quality because of lack of data on quality attributes.

Outputs Each country produced 32 outputs (*Spel*) which were grouped into three major categories, grains, other crops, and animal products. Grains include wheat, barley, rye, oats, flax, pulses and corn.

Potatoes, other tuber crops, all vegetables, fruits, all industrial crops, sugar, flowers, and tobacco constitute 'other crops'. Livestock products include beef, eggs, chicken, mutton, veal, milk, wool, pork and other animals. The above three major output quantities and their unit values were derived as Tornqvist indexes. The database lists the unit values (prices) as market based and accounts for various forms of protection. Real output prices were obtained by deflating the nominal unit values from above by the GDP deflator.

Inputs Inputs were grouped into 8 major categories: Energy and machine repairs, fertilizers and seeds, pesticides and pharmaceutical inputs, feed inputs, animal inputs, capital, land, and labor. Most of the data on intermediates (unit values and quantities for the first five) are from *Spel*, while data on the payments to hired labor and net income (remuneration to capital, land and family labor) are from *EAA*. The total cost of intermediates derived from *Spel* and *EAA* were different largely due to the opportunity cost of animals. The *EAA* takes into account of new animal purchases, while ignoring the opportunity costs of existing stock of animals. The opportunity costs were computed (procedure outlined below) using the data from *Spel*. Data on two-types of land (arable and pasture from *FAO* production yearbooks) and their rental rates were obtained from *The Agricultural Situation in the Community* (European Commission) and aggregated into a single land input. From the payments to capital (*EAA*) the value of land was subtracted to obtain the value of non-land capital[7, 8].

The 8 input quantities and prices were also derived as Tornqvist indices. Expenditure on energy and machine repairs were available in constant 1990 local currency. Data on the use of the three major types of fertilizers, nitrogen, phosphate and potassium (in tons of nutrient) and their unit values (per tonne of nutrient) were combined with the expenditure on seed (in constant 1990 local currency which is multiplied by the unit value deflator to obtain the nominal expenditure). Cost of pesticides and pharmaceutical products were also available in constant 1990 local currency (with unit value deflators). Feed inputs include barley, oats, rye, corn, pulses and feed potatoes (unit values and quantities). The opportunity cost of animal inputs turned out to be the most difficult to measure. Pigs, and chickens are harvested within one year, while non-dairy cattle were either harvested within one year as veal, or in two years as beef. Hence, it was important to make sure that the cost of calves were allocated to the year in which they were harvested. It was assumed that the share of beef and veal in total meat output (exclusive of other animals like pigs, sheep and goat, etc.,) was representative of the percentage of calves harvested in one year (veal), while all other calves were harvested in the second year (beef). The total number of calves were then decomposed into those for veal and for beef. The cost of calves were taken into account for veal directly, and the opportunity cost of calves for beef were computed using IMF market interest rates. The same procedure was applied to non-dairy cows. Capital in constant 1990 local currency for each of the four countries were obtained from Ball et al. (1993) and hired labor data was available in annual work units from *Spel*.

## V. Results

Tables 1A through 1C present the estimates of the contributions to GDP growth in Denmark for the periods 1974-93. Similar estimates are presented for France (Tables 2A-2C), Germany (Tables 3A-3C) and the U.K. (Tables 4A-4C). The results for the U.S. are presented in Tables 5A-5C. As the sample covers the 1970s and 1980s, several sub-period averages are considered including the period 1980-93

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[7] Unfortunately, existing databases are unable to decompose this data series further (Bureau et al., 1995).

[8] For the year 1993, we obtained (I) wage and labor data from the United Nations' 'National Account Systems', and (ii) rental price and stock of capital from Ball (1993).

and four five-year averages. A detailed discussion of individual countries is followed by a comparison of the EU countries with the U.S.

Denmark For Denmark, growth in agricultural GDP averaged 4.40 percent annually over the entire sample period[9]. With declining real prices and almost stable input levels, growth in TFP (5.09 percent) is the major contributor to growth in agricultural GDP. The estimates of components of growth between 1970s and 1980s are significantly different, but the underlying 'stylized facts' remain the same. The post-1980 period witnessed a relatively modest growth in agricultural GDP and TFP at 2.06 percent and 2.90 percent, respectively. Declining prices appear to have larger effects during the post-1980 period, but TFP growth has been the key to growth of agricultural GDP in Denmark. However, the period 1984-93 (particularly 1984, 1987, 1992 and 1993) witnessed large negative growth rates of GDP, and hence the five year averages of TFP growth are also negative. On average, the effects of declining prices averaged -0.65 percent per annum. A decomposition of price effects (Table 1B) shows that declining livestock product and other crop prices have had a larger impact on agricultural GDP than the prices of grains. However, during the post-1980 period the impact of declining grain and other crop prices had a larger impact than the prices of livestock products. Table 1C provides estimates of the contribution from inputs to growth, most of which are relatively small. Intermediate inputs contributed significantly to growth in agricultural GDP during the period 1974-1983. During 1980-93, the inputs declined relatively faster at -0.22 percent per annum.

France France appears to have one of the relatively fast growing agricultural sectors. The growth rates are significantly higher even for the period 1980-1993, when agricultural GDP growth averaged 3.97 percent annually. The price effects and input contributions are similar to Denmark, but the growth rate of TFP is the largest in France (4.45 percent). Five-year averages suggest a pattern of high growth rates of GDP and TFP in the seventies, but in recent years declining prices appear to have had a larger effect. Moreover, TFP's contribution to growth in GDP appears to decline significantly in the later periods of the sample. The declining prices of grains had a larger impact on agricultural GDP growth as compared to the prices of other crops and livestock (Table 2B). Among inputs, mostly intermediates had a relatively large negative effect on agriculture's growth, while land, labor and capital appear not to have impacted growth (Table 2C). TFP growth has consistently been the major contributor to growth in agricultural GDP during the entire period 1974-93.

Germany Growth rate of agricultural GDP in Germany is relatively low at an average annual rate of 1.76 percent during 1974-93. The growth rate falls significantly, to 1.12 percent for the post-1980 periods. The effects of declining prices and input contributions are small and similar for the entire sample period (-0.11 percent and -0.13 percent, respectively). As is the case with Denmark and France, growth in TFP is the single largest contributor to agriculture's GDP in Germany (2 percent), but it shows a downward trend and seems to be highly variable. Individual inputs and prices have relatively small effects on growth except the intermediate inputs (-0.15 percent) and prices of other crops (-0.05 percent), over the period 1974-93.

United Kingdom The growth rate of agricultural GDP in the United Kingdom is the largest among the countries considered here. It averaged a 7.02 percent growth in its GDP during the period 1974-93. However, the growth rate is significantly lower during the post-1980s, at 4.25 percent per annum and exhibits a downward trend over the entire period of the sample. The effect of real prices and input contributions on growth in GDP are relatively small (-0.04 percent and -0.08 percent, respectively). The net effects from level effects do not change significantly after the oil price shocks (0.10-0.22 = -0.12 percent). The major contributor, rather the major source of growth in agricultural GDP has been the

[9] Other data sets including STARS (World Bank) confirm that the growth in agricultural sector was relatively larger than the economy's GDP growth rate for Denmark and France.

growth in TFP in both the entire sample period and all sub periods. TFP growth averaged a 6.40 percent over the entire period, but dropped to 4.37 percent during 1974-83. This growth rate of TFP is second largest following France among the countries studied.[10]

In summary, the following results stand out: (1) agricultural growth in the major European countries is largely dependent on TFP growth; (2) TFP growth rates appear to exhibit high variability and a declining time trend; (3) for the entire period, the real price declines for agriculture were modest suggesting a large degree of insulation from world price movements; and (4) after the introduction of supply control measures (1988-93), prices declined reflecting a move towards world prices.

Comparison with the United States Table 5A through 5C present the results of the growth decomposition for the United States. Growth in agricultural GDP is surprisingly low, at 0.93 percent annually on average over 1974-91. This is due to the declining real prices for agricultural commodities, although growth in agricultural output averaged over 2 percent. The contribution from inputs to growth is relatively small, which is similar to the EU countries. TFP growth, at 2.17 percent per annum, is the major contributor to growth in agricultural GDP. The declining real prices of U.S. agriculture had a larger effect on its GDP, relative to the EU. Unlike EU, the price effects appear to be lower particularly in the later periods of the sample suggesting that the U.S. economy stayed relatively open to agricultural trade. Moreover, TFP growth rates have been relatively stable (Table 5A).

As discussed in section II, the success of a country in exporting depends not on absolute but on comparative productivity advantage (Krugman, 1996). For the U.S. our analysis shows that the ratio of agricultural to non-agricultural productivity growth is about 10 (2.17 percent TFP growth in agriculture and 0.21 percent TFP growth in the entire economy during 1974-91).[11] For the EU countries, agricultural TFP ranged from 6.4 percent for U.K. to 2 percent for Germany. Boskin and Lau (1992) find that their estimate of economy-wide TFP growth rates for the European countries are consistent with most other studies. Their estimate of economy-wide TFP growth rates vary between 1.7 percent for U.K. to 2.9 percent for France. This suggests that the ratio of agricultural to non-agricultural productivity in major EU countries is between 1 and 4. The above reiterates our earlier assertion that competitiveness is a relative concept and the U.S. agriculture has remained competitive largely due to its comparative technological progress.[12] Therefore, the relative competitiveness of U.S. agriculture is likely to depend, largely, on its ability to sustain higher growth in TFP.

TFP growth in U.S. agriculture has been found to be associated strongly with public investments in agricultural specific R&D and public infrastructure (Alston and Pardey 1995, Huffman and Evenson 1993).[13] For a sensitivity analysis of the association of TFP growth with various sources of 'technological externalities' (public R&D, private R&D, infrastructure and learning-by-doing), see Gopinath and Roe (1995). They also find that public agricultural specific R&D is robustly associated with TFP growth. However, the contribution from R&D stock to productivity growth appears to decline, in recent years, largely due to stagnation in federal agricultural specific R&D expenditures.

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[10]Our rates of TFP growth are larger than those obtained by Bureau et al. (1995), but, as will be seen in the next sub-section, they do not change the results on comparative productivity advantage.

[11]See Gopinath and Roe (1996) for the computation of TFP growth rates for the U.S. economy.

[12]Note that a comparison using GDP growth rates will lead to slightly different results, but technology (TFP growth) is key to long-term competitiveness.

[13]We are not able to comment about sources of European TFP growth because the data on R&D, and infrastructure are not available.

# VI. Summary and Conclusions

Agricultural growth in the U.S. and major EU countries is decomposed into short-run level effects (prices and inputs) and long-run rate effects (TFP) in the context of the broader economy. Sources of growth in agriculture's TFP are likely to be outside the sector, which are referred to as technological externalities and include public investments in R&D, public infrastructure, learning-by-doing and other social investments.

For the four major European countries, Denmark, France, Germany and the U.K. the major source of growth in agricultural GDP is TFP. France and the U.K. have relatively large rates of growth in GDP and TFP, followed by Denmark. The growth in German agricultural sector has been relatively small. Except for Germany, the other EU countries' agricultural terms of trade with the rest of the economy have declined, but the effect on growth in GDP is relatively small. These price effects suggest that the CAP policies have adequately insulated agricultural producers against adverse domestic terms of trade. Input contributions to growth in agriculture are relatively small. In the last period of the sample (1988-93), real prices are falling rapidly and there is a downward trend in the rates of growth of TFP.

For the U.S., TFP is the major source of growth in agricultural GDP, but its rate of growth is lower than the European countries for the same period. The declining real prices for U.S. agriculture had a relatively large effect on its GDP, on average. However, U.S. agriculture shows a relatively stable growth in its TFP throughout the sample period and in the 1980's the adverse effects from declining real prices are relatively small. In the longer run, the relative competitiveness of U.S. agriculture is likely to depend on its ability to sustain and increase growth in TFP.

Table 1A. Components of Agricultural GDP growth in Denmark

| | GDP growth | Price effect | Input Contribution | TFP growth |
|---|---|---|---|---|
| 1974-1993 | 4.40 | -0.65 | -0.04 | 5.09 |
| 1980-1993 | 2.06 | -0.62 | -0.22 | 2.90 |
| 1974-1978 | 11.16 | -0.29 | 0.69 | 10.77 |
| 1979-1983 | 11.99 | -0.23 | 0.07 | 12.14 |
| 1984-1988 | -2.70 | 0.23 | -0.91 | -2.02 |
| 1989-1993 | -2.88 | -2.32 | 0.01 | -0.56 |

Table 1B. Price effects on Agricultural GDP growth in Denmark

| | Aggregate Price | Grains | Other crops | Livestock |
|---|---|---|---|---|
| 1974-1993 | -0.65 | -0.15 | -0.25 | -0.25 |
| 1980-1993 | -0.62 | -0.32 | -0.35 | 0.05 |
| 1974-1978 | -0.29 | -0.06 | 0.08 | -0.32 |
| 1979-1983 | -0.23 | -0.38 | 0.25 | -0.11 |
| 1984-1988 | 0.23 | 0.17 | -0.52 | 0.59 |
| 1989-1993 | -2.32 | -0.34 | -0.81 | -1.18 |

Table 1C. Input contributions to Agricultural GDP growth in Denmark

| | Aggregate Inputs | Land | Labor | Capital | Intermediates |
|---|---|---|---|---|---|
| 1974-1993 | -0.04 | -0.00 | -0.00 | -0.03 | -0.00 |
| 1980-1993 | -0.22 | -0.01 | 0.02 | -0.13 | -0.10 |
| 1974-1978 | 0.69 | 0.00 | -0.05 | 0.21 | 0.53 |
| 1979-1983 | 0.07 | -0.02 | 0.03 | -0.37 | 0.42 |
| 1984-1988 | -0.91 | 0.01 | -0.07 | 0.05 | -0.91 |
| 1989-1993 | 0.01 | -0.01 | 0.08 | 0.01 | -0.07 |

Table 2A. Components of Agricultural GDP growth in France

| | GDP growth | Price effect | Input Contribution | TFP growth |
|---|---|---|---|---|
| 1974-1993 | 5.24 | -0.62 | -0.18 | 6.04 |
| 1980-1993 | 3.97 | -0.05 | -0.43 | 4.45 |
| 1974-1978 | 6.96 | -2.65 | 0.49 | 9.12 |
| 1979-1983 | 11.73 | 1.02 | -0.31 | 11.02 |
| 1984-1988 | 3.47 | 1.43 | -0.04 | 2.08 |
| 1989-1993 | -1.18 | -2.27 | -0.85 | 1.94 |

Table 2B. Price effects on Agricultural GDP growth in France

| | Aggregate Price | Grain | Other crops | Livestock |
|---|---|---|---|---|
| 1974-1993 | -0.62 | -0.37 | -0.06 | -0.19 |
| 1980-1993 | -0.05 | -0.40 | 0.22 | 0.12 |
| 1974-1978 | -2.65 | -0.45 | -1.07 | -1.12 |
| 1979-1983 | 1.02 | 0.13 | 0.85 | 0.03 |
| 1984-1988 | 1.43 | 0.31 | 0.24 | 0.88 |
| 1989-1993 | -2.27 | -1.46 | -0.24 | -0.56 |

Table 2C. Input contributions to Agricultural GDP growth in France

| | Aggregate Inputs | Land | Labor | Capital | Intermediates |
|---|---|---|---|---|---|
| 1974-1993 | -0.18 | -0.00 | -0.02 | 0.00 | -0.17 |
| 1980-1993 | -0.43 | 0.00 | -0.02 | -0.09 | -0.33 |
| 1974-1978 | 0.49 | 0.00 | -0.02 | 0.16 | 0.34 |
| 1979-1983 | -0.31 | -0.01 | -0.02 | 0.02 | -0.31 |
| 1984-1988 | -0.04 | -0.01 | -0.01 | -0.16 | 0.15 |
| 1989-1993 | -0.85 | 0.01 | -0.02 | 0.01 | -0.85 |

Table 3A. Components of Agricultural GDP growth in Germany

| | GDP growth | Price effect | Input Contribution | TFP growth |
|---|---|---|---|---|
| 1974-1993 | 1.76 | -0.11 | -0.13 | 2.00 |
| 1980-1993 | 1.12 | -0.13 | -0.11 | 1.36 |
| | | | | |
| 1974-1978 | 3.59 | -1.46 | -0.01 | 5.05 |
| 1979-1983 | 3.33 | 1.37 | -0.15 | 2.11 |
| 1984-1988 | -1.65 | 0.22 | -0.10 | -1.76 |
| 1989-1993 | 1.78 | -0.59 | -0.23 | 2.60 |

Table 3B. Price effects on Agricultural GDP growth in Germany

| | Aggregate Price | Grain | Other crops | Livestock |
|---|---|---|---|---|
| 1974-1993 | -0.11 | -0.04 | -0.05 | -0.02 |
| 1980-1993 | -0.13 | -0.01 | -0.15 | 0.03 |
| | | | | |
| 1974-1978 | -1.46 | -0.15 | -0.43 | -0.89 |
| 1979-1983 | 1.37 | 0.04 | 0.67 | 0.67 |
| 1984-1988 | 0.22 | 0.09 | -0.39 | 0.51 |
| 1989-1993 | -0.59 | -0.13 | -0.07 | -0.39 |

Table 3C. Input contributions to Agricultural GDP growth in Germany

| | Aggregate Inputs | Land | Labor | Capital | Intermediates |
|---|---|---|---|---|---|
| 1974-1993 | -0.13 | 0.01 | -0.01 | 0.02 | -0.15 |
| 1980-1993 | -0.11 | 0.02 | -0.00 | -0.03 | -0.10 |
| | | | | | |
| 1974-1978 | -0.01 | -0.00 | -0.02 | 0.15 | -0.13 |
| 1979-1983 | -0.15 | -0.00 | 0.02 | -0.19 | 0.02 |
| 1984-1988 | -0.10 | 0.01 | 0.01 | -0.02 | -0.10 |
| 1989-1993 | -0.23 | 0.05 | -0.04 | 0.13 | -0.37 |

Table 4A. Components of Agricultural GDP growth in U.K.

| | GDP growth | Price effect | Input Contribution | TFP growth |
|---|---|---|---|---|
| 1974-1993 | 7.02 | -0.04 | -0.08 | 6.40 |
| 1980-1993 | 4.25 | 0.10 | -0.22 | 4.37 |
| | | | | |
| 1974-1978 | 12.49 | -1.82 | 0.48 | 13.83 |
| 1979-1983 | 11.53 | 1.57 | -0.11 | 10.07 |
| 1984-1988 | 0.87 | -1.13 | -0.48 | 2.49 |
| 1989-1993 | 3.18 | 1.23 | -0.18 | 2.13 |

Table 4B. Price effects on Agricultural GDP growth in U.K.

| | Aggregate Price | Grain | Other crops | Livestock |
|---|---|---|---|---|
| 1974-1993 | -0.04 | -0.08 | -0.15 | 0.19 |
| 1980-1993 | 0.10 | -0.13 | -0.25 | 0.48 |
| | | | | |
| 1974-1978 | -1.82 | -0.28 | -1.01 | -0.53 |
| 1979-1983 | 1.57 | 0.52 | 1.26 | -0.21 |
| 1984-1988 | -1.13 | -0.78 | -0.73 | 0.38 |
| 1989-1993 | 1.23 | 0.23 | -0.13 | 1.12 |

Table 4C. Input contributions to Agricultural GDP growth in U.K.

| | Aggregate Inputs | Land | Labor | Capital | Intermediates |
|---|---|---|---|---|---|
| 1974-1993 | -0.08 | -0.03 | -0.01 | -0.01 | -0.04 |
| 1980-1993 | -0.22 | -0.04 | 0.01 | -0.08 | -0.12 |
| | | | | | |
| 1974-1978 | 0.48 | -0.00 | -0.01 | 0.21 | 0.27 |
| 1979-1983 | -0.11 | -0.01 | -0.01 | -0.10 | 0.01 |
| 1984-1988 | -0.48 | -0.00 | -0.03 | -0.12 | -0.33 |
| 1989-1993 | -0.18 | -0.09 | 0.03 | -0.01 | -0.11 |

Table 5A Components of Agricultural GDP growth in the United States

| | GDP growth | Price Effect | Input Contribution | TFP growth |
|---|---|---|---|---|
| 1974-91 | 0.93 | -1.23 | -0.01 | 2.17 |
| 1980-91 | 0.63 | -0.53 | -0.93 | 2.09 |
| 1974-77 | 2.80 | -0.69 | 1.00 | 2.48 |
| 1978-82 | -0.39 | -2.92 | 0.62 | 1.92 |
| 1983-87 | -1.68 | -2.43 | -1.91 | 2.65 |
| 1988-91 | 3.52 | 1.72 | 0.29 | 1.51 |

Table 5B Price Effects on Agricultural GDP growth in the United States

| | Price Effects | Meat | Dairy | Grain | Ocrops |
|---|---|---|---|---|---|
| 1974-91 | -1.23 | -0.18 | -0.10 | -0.62 | -0.32 |
| 1980-91 | -0.53 | 0.09 | -0.26 | -0.47 | 0.11 |
| 1974-77 | -0.69 | -0.93 | 0.53 | -0.66 | 0.37 |
| 1978-82 | -2.92 | 0.10 | -0.40 | -0.81 | -1.81 |
| 1983-87 | -2.43 | -0.46 | -0.76 | -0.77 | -0.44 |
| 1988-91 | 1.72 | 0.75 | 0.31 | -0.15 | 0.81 |

Table 5C Input Contributions to Agricultural GDP growth in the United States

| | Input Contribution | Labor | Capital | Real Prope | Materials |
|---|---|---|---|---|---|
| 1973-91 | -0.01 | -0.26 | 0.42 | -0.09 | -0.07 |
| 1980-91 | -0.93 | -0.20 | -0.03 | -0.35 | -0.35 |
| 1973-77 | 1.00 | -0.41 | 0.80 | 0.33 | 0.29 |
| 1978-82 | 0.62 | -0.24 | 0.84 | -0.05 | 0.06 |
| 1983-87 | -1.91 | -0.59 | -0.24 | -0.58 | -0.50 |
| 1988-91 | 0.29 | 0.29 | 0.23 | -0.06 | -0.17 |

## References


Arnade, C. (1995). *Productivity Growth in 76 Countries.* Economic Research Service, U.S. Department of Agriculture, Washington D.C.

Ball, V. E. , J. C. Bureau, R. Nehring and A. Somwaru (1995). *Agricultural Productivity Revisited.* U.S. Dept. Agr. Econ. Res. Serv. (forthcoming).

Ball, V. E., J. C. Bureau, J. P. Butault and H. P. Witke (1993). "The Stock of Capital in European Community Agriculture." *European Review of Agricultural Economics*, 20: 437-450.

Boskin, M.J., and L.J. Lau (1992). *Post-war Economic Growth in the Group of Five Countries: A New Perspective.* Technical Paper, Stanford University, Stanford.

Bureau, J-C., R. Fare and S. Grosskopf (1995). "A Comparison of Three Nonparametric Measures of Productivity Growth in European and United States Agriculture." *Journal of Agricultural Economics*, 46(3):309-326.

Diewert, W.E. (1974). "Applications of Duality Theory." In *Frontiers of Quantitative Economics*, Volume II Intriligator, M. D. and D. A. Kendrick (ed.), North-Holland, Amsterdam.

Diewert, W.E. (1976). "Exact and Superlative Index Numbers." *Journal of Econometrics* 4:115-145.

Diewert, W.E., (1980). "Aggregation Problems in the Measurement of Capital." In *The Measurement of Capital,* Studies in Income and Wealth, Vol. 45 Usher, D. (ed.), National Bureau of Economic Research, Cambridge.

Diewert, W.E., and C.J. Morrison (1986). "Adjusting Output and Productivity Indexes for Changes in Terms of Trade." *The Economic Journal*, 96:659-679.

European Commission, The Agricultural Situation in the Community, 1973-93.

Eurostat, *Spel* electronic data base, 1973-93.

FAO, Production yearbook, 1973-1993

Gopinath, M., and T. L. Roe (1996). "Sources of Growth in U.S. GDP and Economy Wide Linkages to the Agricultural Sector." *Journal of Agricultural and Resource Economics* (forthcoming).

Gopinath, M., and T. L. Roe (1995). *Sources of Sectoral Growth in an Economy-Wide Context: The Case of U.S. Agriculture*, Bulletin 95-7, Economic Development Center, University of Minnesota, Minneapolis-St. Paul.

Kohli, U.R.,(1993). "GNP Growth Accounting in the Open Economy: Parametric and Non-parametric Estimates for Switzerland." *Swedish Journal of Economics and Statistics*, 129:601-615.

Krugman, P. (1996). *Peddling Prosperity: Economic Sense and Non-Sense in the Age of Diminished Expectations.* Norton Publishing Co. New York.

Landau, R. (1992). "Technology, Capital Formation and U.S. Competitiveness." In *International Productivity and Competitiveness,* Hickman B.G. (ed.), Oxford University Press, New York.

Lucas, R.E.(1993). "Making a Miracle." *Econometrica*, 61(2):251-272.

OECD Agricultural Statistics, Economic Accounts for Agriculture, 1973-1992.

Romer, P.M. (1990). "Endogenous Technological Change." *Journal of Political Economy*, 98(5):s71-s102.

Stokey, N.L. (1988). "Learning by Doing and the Introduction of New Goods", *Journal of Political Economy*, 96:701-717.

Woodland, A.D. (1982). *International Trade and Resource Allocation.* North- Holland, Amsterdam.